4.3 More Discrete Probability Distributions

What You SHOULD LEARN

- How to find probabilities using the geometric distribution
- How to find probabilities using the Poisson distribution

The Geometric Distribution ▸ The Poisson Distribution ▸ Summary of Discrete Probability Distributions

▸ The Geometric Distribution

In this section, you will study two more discrete probability distributions—the geometric distribution and the Poisson distribution.

Many actions in life are repeated until a success occurs. For instance, a CPA candidate might take the CPA exam several times before receiving a passing score, or you might have to dial a cellular phone number several times before successfully being connected. Situations such as these can be represented by a geometric distribution.

DEFINITION

A **geometric distribution** is a discrete probability distribution of a random variable x that satisfies the following conditions.

1. A trial is repeated until a success occurs.
2. The repeated trials are independent of each other.
3. The probability of success p is constant for each trial.

The **probability that the first success will occur on trial number** x is

$$P(x) = p(q)^{x-1}, \text{ where } q = 1 - p.$$

Study Tip

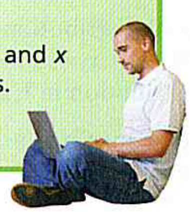
Detailed instructions for finding a geometric probability on a TI-83/84.

2nd DISTR

D: geometpdf(

Enter the values of p and x separated by commas.

ENTER



In other words, when the first success occurs on the third trial, the outcome is FFS, and the probability is $P(3) = q \cdot q \cdot p$, or $P(3) = p \cdot q^2$.

EXAMPLE 1

Finding Probabilities Using the Geometric Distribution

From experience, you know that the probability that you will make a sale on any given telephone call is 0.23. Find the probability that your first sale on any given day will occur on your fourth or fifth sales call.

Solution To find the probability that your first sale will occur on the fourth or fifth call, first find the probability that the sale will occur on the fourth call and the probability that the sale will occur on the fifth call. Then find the sum of the resulting probabilities. Using $p = 0.23$, $q = 0.77$, and $x = 4$, you have

$$P(4) = 0.23 \cdot (0.77)^3 \approx 0.105003.$$

Using $p = 0.23$, $q = 0.77$, and $x = 5$, you have

$$P(5) = 0.23 \cdot (0.77)^4 \approx 0.080852.$$

So, the probability that your first sale will occur on the fourth or fifth sales call is

$$\begin{aligned} P(\text{sale on fourth or fifth call}) &= P(4) + P(5) \\ &\approx 0.105003 + 0.080852 \\ &\approx 0.186. \end{aligned}$$

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geometpdf(.23,4)
          .10500259
geometpdf(.23,5)
        .0808519943
```

Using a TI-83/84, you can find the probabilities used in Example 1 automatically.

Try It Yourself 1

Find the probability that your first sale will occur before your fourth sales call.

a. *Use the geometric distribution* to find $P(1)$, $P(2)$, and $P(3)$.
b. *Find the sum* of $P(1)$, $P(2)$, and $P(3)$.
c. *Write* the result as a sentence.

Answer: Page A40

Even though theoretically a success may never occur, the geometric distribution is a discrete probability distribution because the values of x can be listed—1, 2, 3, ... Notice that as x becomes larger, $P(x)$ gets closer to zero. For instance

$$P(50) = 0.23(0.77)^{49}$$
$$\approx 0.0000006306.$$

The Poisson Distribution

In a binomial experiment you are interested in finding the probability of a specific number of successes in a given number of trials. Suppose instead that you want to know the probability that a specific number of occurrences takes place within a given unit of time or space. For instance, to determine the probability that an employee will take 15 sick days within a year, you can use the Poisson distribution.

DEFINITION

The **Poisson distribution** is a discrete probability distribution of a random variable x that satisfies the following conditions.

1. The experiment consists of counting the number of times, x, an event occurs in a given interval. The interval can be an interval of time, area, or volume.
2. The probability of the event occurring is the same for each interval.
3. The number of occurrences in one interval is independent of the number of occurrences in other intervals.

The probability of exactly x occurrences in an interval is

$$P(x) = \frac{\mu^x e^{-\mu}}{x!}$$

where e is an irrational number approximately equal to 2.71828 and μ is the mean number of occurrences per interval unit.

EXAMPLE 2

Using the Poisson Distribution

The mean number of accidents per month at a certain intersection is three. What is the probability that in any given month four accidents will occur at this intersection?

Solution Using $x = 4$ and $\mu = 3$, the probability that 4 accidents will occur in any given month at the intersection is

$$P(4) = \frac{3^4(2.71828)^{-3}}{4!}$$
$$\approx 0.168.$$

▸ Try It Yourself 2

What is the probability that more than four accidents will occur in any given month at the intersection?

a. *Use the Poisson distribution* to find $P(0)$, $P(1)$, $P(2)$, $P(3)$, and $P(4)$.
b. *Find the sum* of $P(0)$, $P(1)$, $P(2)$, $P(3)$, and $P(4)$.
c. *Subtract* the sum from 1.
d. *Write* the result as a sentence.

Answer: Page A40

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poissonpdf(3,4)
        .1680313557
```
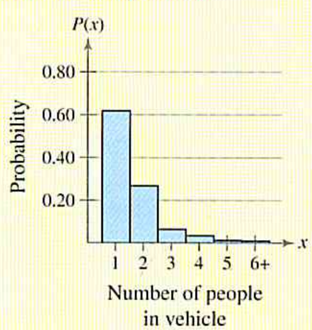

In Example 2 you used a formula to determine a Poisson probability. You can also use a table to find Poisson probabilities. Table 3 in Appendix B lists the Poisson probability for selected values of x and μ. You can use technology tools, such as MINITAB, Excel, and the TI-83/84, to find Poisson probabilities as well. For example, on a TI-83/84, the DISTR menu can be used to find binomial, geometric, and Poisson probabilities. The solution for Example 2 is shown in the margin.

PICTURING the WORLD

The first successful suspension bridge built in the United States, the Tacoma Narrows Bridge, spans the Tacoma Narrows in Washington State. The average occupancy of vehicles that travel across the bridge is 1.6. The following probability distribution represents the vehicle occupancy on the bridge during a five-day period. (Source: Washington State Department of Transportation)



What is the probability that a randomly selected vehicle has two occupants or fewer?

EXAMPLE 3

Finding Poisson Probabilities Using a Table

A population count shows that there is an average of 3.6 rabbits per acre living in a field. Use a table to find the probability that two rabbits are found on any given acre of the field.

Solution A portion of Table 3 in Appendix B is shown here. Using the distribution for $\mu = 3.6$ and $x = 2$, you can find the Poisson probability as shown by the highlighted areas in the table.

	μ						
x	**3.1**	**3.2**	**3.3**	**3.4**	**3.5**	**3.6**	**3.7**
0	.0450	.0408	.0369	.0334	.0302	.0273	.0247
1	.1397	.1304	.1217	.1135	.1057	.0984	.0915
2	.2165	.2087	.2008	.1929	.1850	.1771	.1692
3	.2237	.2226	.2209	.2186	.2158	.2125	.2087
4	.1734	.1781	.1823	.1858	.1888	.1912	.1931
5	.1075	.1140	.1203	.1264	.1322	.1377	.1429
6	.0555	.0608	.0662	.0716	.0771	.0826	.0881
7	.0246	.0278	.0312	.0348	.0385	.0425	.0466
8	.0095	.0111	.0129	.0148	.0169	.0191	.0215
9	.0033	.0040	.0047	.0056	.0066	.0076	.0089
10	.0010	.0013	.0016	.0019	.0023	.0028	.0033

So, the probability that two rabbits are found on any given acre is 0.1771.

▸ Try It Yourself 3

Two thousand brown trout are introduced into a small lake. The lake has a volume of 20,000 cubic meters. Use a table to find the probability that three brown trout are found in any given cubic meter of the lake.

a. *Find the average* number of brown trout per cubic meter.
b. *Identify* μ and x.
c. *Use Table 3* in Appendix B to find the Poisson probability.
d. *Write* the result as a sentence.

Answer: Page A40

Summary of Discrete Probability Distributions

The following table summarizes the discrete probability distributions discussed in this chapter.

Distribution	Summary	Formulas
Binomial Distribution	A binomial experiment satisfies the following conditions. **1.** The experiment is repeated for a fixed number (n) of independent trials. **2.** There are only two possible outcomes for each trial. Each outcome can be classified as a success or as a failure. **3.** The probability of a success must remain constant for each trial. **4.** The random variable x counts the number of successful trials out of the n trials. The parameters of a binomial distribution are n and p.	x = the number of successes in n trials p = probability of success in a single trial q = probability of failure in a single trial $q = 1 - p$ The probability of exactly x successes in n trials is $P(x) = {}_nC_x p^x q^{n-x} = \frac{n!}{(n-x)!x!} p^x q^{n-x}.$
Geometric Distribution	A geometric distribution is a discrete probability distribution of a random variable x that satisfies the following conditions. **1.** A trial is repeated until a success occurs. **2.** The repeated trials are independent of each other. **3.** The probability of success p is constant for each trial. **4.** The random variable x represents the number of the trial in which the first success occurs. The parameter of a geometric distribution is p.	x = the number of the trial in which the first success occurs p = probability of success in a single trial q = probability of failure in a single trial $q = 1 - p$ The probability that the first success occurs on trial number x is $P(x) = p(q)^{x-1}.$
Poisson Distribution	The Poisson distribution is a discrete probability distribution of a random variable x that satisfies the following conditions. **1.** The experiment consists of counting the number of times, x, an event occurs over a specified interval of time, area, or volume. **2.** The probability of the event occurring is the same for each interval. **3.** The number of occurrences in one interval is independent of the number of occurrences in other intervals. The parameter of a Poisson distribution is μ.	x = the number of occurrences in the given interval μ = the mean number of occurrences in a given time or space unit The probability of exactly x occurrences in an interval is $P(x) = \frac{\mu^x e^{-\mu}}{x!}.$

4.3 EXERCISES

Building Basic Skills and Vocabulary

In Exercises 1–4, assume the geometric distribution applies. Use the given probability of success p to find the indicated probability.

1. Find $P(2)$ when $p = 0.60$.

2. Find $P(1)$ when $p = 0.25$.

3. Find $P(6)$ when $p = 0.09$.

4. Find $P(5)$ when $p = 0.38$.

In Exercises 5–8, assume the Poisson distribution applies. Use the given mean μ to find the indicated probability.

5. Find $P(3)$ when $\mu = 4$.

6. Find $P(5)$ when $\mu = 6$.

7. Find $P(2)$ when $\mu = 1.5$.

8. Find $P(4)$ when $\mu = 8.1$.

9. In your own words, describe the difference between the value of x in a binomial distribution and in a geometric distribution.

10. In your own words, describe the difference between the value of x in a binomial distribution and in a Poisson distribution.

Deciding on a Distribution *In Exercises 11–16, decide which probability distribution—binomial, geometric, or Poisson—applies to the question. You do not need to answer the question. Instead, justify your choice.*

11. Pilot's Test *Given:* The probability that a student passes the written test for a private pilot's license is 0.75. *Question:* What is the probability that a student will fail the test on the first attempt and pass it on the second attempt?

12. Precipitation *Given:* In Rapid City, South Dakota, the mean number of days with 0.01 inch or more precipitation for May is 12. *Question:* What is the probability that Rapid City has 18 days with 0.01 inch or more precipitation next May? *(Source: National Climatic Data Center)*

13. Oil Tankers *Given:* The mean number of oil tankers at a port city is 8 per day. The port has facilities to handle up to 12 oil tankers in a day. *Question:* What is the probability that too many tankers will arrive on a given day?

14. Exercise *Given:* Forty percent of adults in the United States exercise at least 30 minutes a week. In a survey of 120 randomly chosen adults, people were asked, "Do you exercise at least 30 minutes a week?" *Question:* What is the probability that exactly 50 of the people answer yes?

15. Cheaters *Given:* Of students ages 16 to 18 with A or B averages who plan to attend college after graduation, 78% cheated to get higher grades. Ten randomly chosen students with A or B averages who plan to attend college after graduation were asked, "Did you cheat to get higher grades?" *Question:* What is the probability that exactly two students answered no? *(Source: Who's Who Among American High School Students)*

16. No Meat? *Given:* About 21% of Americans say they could not go one week without eating meat. You select at random 20 Americans. *Question:* What is the probability that the first person who says he or she cannot go one week without eating meat is the fifth person selected? *(Source: Reuters/Zogby)*

Using and Interpreting Concepts

Using a Geometric Distribution to Find Probabilities *In Exercises 17–20, find the indicated probabilities using the geometric distribution. If convenient, use technology to find the probabilities.*

17. Telephone Sales Assume the probability that you will make a sale on any given telephone call is 0.19. Find the probability that you (a) make your first sale on the fifth call, (b) make your first sale on the first, second, or third call, and (c) do not make a sale on the first three calls.

18. Free Throws Basketball player Shaquille O'Neal makes a free-throw shot about 52.6% of the time. Find the probability that (a) the first shot O'Neal makes is the second shot, (b) the first shot O'Neal makes is the first or second shot, and (c) O'Neal does not make two shots. *(Source: National Basketball Association)*

19. Glass Manufacturer A glass manufacturer finds that 1 in every 500 glass items produced is warped. Find the probability that (a) the first warped glass item is the tenth item produced, (b) the first warped glass item is the first, second, or third item produced, and (c) none of the first 10 glass items produced are defective.

20. Winning a Prize A cereal maker places a game piece in its cereal boxes. The probability of winning a prize in the game is 1 in 4. Find the probability that you (a) win your first prize with your fourth purchase, (b) win your first prize with your first, second, or third purchase, and (c) do not win a prize with your first four purchases.

Using a Poisson Distribution to Find Probabilities *In Exercises 21–24, find the indicated probabilities using the Poisson distribution. If convenient, use a Poisson probability table or technology tool to find the probabilities.*

21. Bankruptcies The mean number of bankruptcies filed per minute in the United States in a recent year was about three. Find the probability that (a) exactly five businesses will file bankruptcy in any given minute, (b) at least five businesses will file bankruptcy in any given minute, and (c) more than five businesses will file bankruptcy in any given minute. *(Source: Administrative Office of the U.S. Courts)*

22. Typographical Errors A newspaper finds that the mean number of typographical errors per page is four. Find the probability that (a) exactly three typographical errors will be found on a page, (b) at most three typographical errors will be found on a page, and (c) more than three typographical errors will be found on a page.

23. Major Hurricanes A major hurricane is a hurricane with wind speeds of 111 miles per hour or greater. During the 20th century, the mean number of major hurricanes to strike the U.S. mainland per year was about 0.6. Find the probability that in a given year (a) exactly one major hurricane will strike the U.S. mainland, (b) at most one major hurricane will strike the U.S. mainland, and (c) more than one major hurricane will strike the U.S. mainland. *(Source: National Hurricane Center)*

24. Precipitation The mean number of days with 0.01 inch or more precipitation per month for Lewistown, Idaho, is about 8.7. Find the probability that in a given month (a) there are exactly 9 days with 0.01 inch or more precipitation, (b) there are at most 9 days with 0.01 inch or more precipitation, and (c) there are more than 9 days with 0.01 inch or more precipitation. *(Source: National Climatic Data Center)*

Extending Concepts

25. Approximating the Binomial Distribution An automobile manufacturer finds that 1 in every 2500 automobiles produced has a particular manufacturing defect. (a) Use a binomial distribution to find the probability of finding four cars with the defect in a random sample of 6000 cars. (b) The Poisson distribution can be used to approximate the binomial distribution for large values of n and small values of p. Repeat (a) using a Poisson distribution and compare the results.

26. Hypergeometric Distribution Binomial experiments require that any sampling be done with replacement because each trial must be independent of the others. The **hypergeometric distribution** also has two outcomes—success and failure. However, the sampling is done without replacement. Given a population of N items having k successes and $N - k$ failures, the probability of selecting a sample of size n that has x successes and $n - x$ failures is given by

$$P(x) = \frac{({}_kC_x)({}_{N-k}C_{n-x})}{{}_NC_n}.$$

In a shipment of 15 microchips, 2 are defective and 13 are not defective. A sample of three microchips is chosen at random. Find the probability that (a) all three microchips are not defective, (b) one microchip is defective and two are not defective, and (c) two microchips are defective and one is not defective.

Geometric Distribution: Mean and Variance *In Exercises 27 and 28, use the fact that the mean of a geometric distribution is $\mu = 1/p$ and the variance is $\sigma^2 = q/p^2$.*

27. Daily Lottery A daily number lottery chooses three balls numbered 0 to 9. The probability of winning the lottery is 1/1000. Let x be the number of times you play the lottery before winning the first time. (a) Find the mean, variance, and standard deviation. Interpret the results. (b) How many times would you expect to have to play the lottery before winning? Assume that it costs \$1 to play and winners are paid \$500. Would you expect to make or lose money playing this lottery? Explain.

28. Paycheck Errors A company assumes that 0.5% of the paychecks for a year were calculated incorrectly. The company has 200 employees and examines the payroll records from one month. (a) Find the mean, variance, and standard deviation. Interpret the results. (b) How many employee payroll records would you expect to examine before finding one with an error?

Poisson Distribution: Variance *In Exercises 29 and 30, use the fact that the variance of a Poisson distribution is $\sigma^2 = \mu$.*

29. Tiger Woods In a recent year, the mean number of strokes per hole for golfer Tiger Woods was about 3.8. (a) Find the variance and standard deviation. Interpret the results. (b) How likely is Woods to play an 18-hole round and have more than 72 strokes? *(Source: PGATour.com)*

30. Snowfall The mean snowfall in January for Bridgeport, Connecticut is 7.6 inches. (a) Find the variance and standard deviation. Interpret the results. (b) Find the probability that the snowfall in January for Bridgeport, Connecticut will exceed 12 inches. *(Source: National Climatic Data Center)*

4 CHAPTER SUMMARY

What did you learn?	EXAMPLE(S)	REVIEW EXERCISES
Section 4.1		
How to distinguish between discrete random variables and continuous random variables	*1*	*1–4*
How to determine if a distribution is a probability distribution	*3–4*	*5–10*
How to construct a discrete probability distribution and its graph and find the mean, variance, and standard deviation of a discrete probability distribution $\mu = \Sigma x P(x)$ $\sigma^2 = \Sigma(x-\mu)^2 P(x)$ $\sigma = \sqrt{\sigma^2} = \sqrt{\Sigma(x-\mu)^2 P(x)}$.	*2, 5, 6*	*11–14*
How to find the expected value of a discrete probability distribution	*7*	*15, 16*
Section 4.2		
How to determine if a probability experiment is a binomial experiment	*1*	*17, 18*
How to find binomial probabilities using the binomial probability formula, a binomial probability table, and technology $P(x) = {}_nC_x p^x q^{n-x} = \frac{n!}{(n-x)!x!} p^x q^{n-x}$	*2, 4–6*	*19–22*
How to construct a binomial distribution and its graph and find the mean, variance, and standard deviation of a binomial probability distribution $\mu = np$ $\sigma^2 = npq$ $\sigma = \sqrt{npq}$	*3, 7, 8*	*23–26*
Section 4.3		
How to find probabilities using the geometric distribution $P(x) = pq^{x-1}$	*1*	*27, 28*
How to find probabilities using the Poisson distribution $P(x) = \frac{\mu^x e^{-\mu}}{x!}$	*2, 3*	*29, 30*

4 REVIEW EXERCISES

Section 4.1

In Exercises 1–4, decide whether the random variable x is discrete or continuous.

1. x represents the number of pumps in use at a gas station.

2. x represents the weight of a truck at a weigh station.

3. x represents the amount of gas pumped at a gas station.

4. x represents the number of people that activate a metal detector at an airport each hour.

In Exercises 5–10, decide whether the distribution is a probability distribution. If it is not, identify the property that is not satisfied.

5. The daily limit for catching bass at a lake is four. The random variable x represents the number of fish caught in a day.

x	0	1	2	3	4
$P(x)$	0.36	0.23	0.08	0.14	0.29

6. The random variable x represents the number of tickets a police officer writes out each shift.

x	0	1	2	3	4	5
$P(x)$	0.09	0.23	0.29	0.16	0.21	0.02

7. A greeting card shop keeps records of customers' buying habits. The random variable x represents the number of cards sold to an individual customer in a shopping visit.

x	1	2	3	4	5	6	7
$P(x)$	0.68	0.14	0.08	0.05	0.02	0.02	0.01

8. The random variable x represents the number of classes in which a student is enrolled in a given semester at a university.

x	1	2	3	4	5	6	7	8
$P(x)$	$\frac{1}{80}$	$\frac{2}{75}$	$\frac{1}{10}$	$\frac{12}{25}$	$\frac{27}{20}$	$\frac{1}{5}$	$\frac{2}{25}$	$\frac{1}{120}$

9. In a survey, Internet users were asked how many e-mail addresses they have. The random variable x represents the number of e-mail addresses.

x	1	2	3
$P(x)$	0.26	0.31	0.43

10. The random variable x represents the number of employees at a company that call in sick per day.

x	0	1	2	3	4	5	6
$P(x)$	0.156	0.318	0.227	0.091	0.136	0.045	0.045

In Exercises 11–14,

(a) use the frequency distribution table to construct a probability distribution.

(b) graph the probability distribution using a histogram.

(c) find the mean, variance, and standard deviation of the probability distribution.

11. The number of pages in a section from a sample of statistics texts

Pages	Sections
2	3
3	12
4	72
5	115
6	169
7	120
8	83
9	48
10	22
11	6

12. The number of hits per game played by a baseball player during a recent season

Hits	Games
0	29
1	62
2	33
3	12
4	3
5	1

13. A survey asked 200 households how many televisions they owned.

Televisions	Households
0	3
1	38
2	83
3	52
4	18
5	5
6	1

14. A television station sells advertising in 15-, 30-, 60-, 90-, and 120-second blocks. The distribution of sales for one 24-hour day is given.

Length (in seconds)	Number
15	76
30	445
60	30
90	3
120	12

In Exercises 15 and 16, find the expected value of the random variable.

15. A person has shares of eight different stocks. The random variable x represents the number of stocks showing a loss on a selected day.

x	0	1	2	3	4	5	6	7	8
$P(x)$	0.02	0.11	0.18	0.32	0.15	0.09	0.05	0.05	0.03

16. A local pub has a chicken wing special on Tuesdays. The pub owners purchase wings in cases of 300. The random variable x represents the number of cases used during the special.

x	1	2	3	4
$P(x)$	$\frac{1}{9}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{18}$

Section 4.2

In Exercises 17 and 18, decide whether the experiment is a binomial experiment. If it is not, identify the property that is not satisfied. If it is, list the values of n, p, and q and the values that x can assume.

17. Bags of plain M&M's contain 24% blue candies. One candy is selected from each of 12 bags. The random variable represents the number of blue candies selected. *(Source: Mars, Inc.)*

18. A fair coin is tossed repeatedly until 15 heads are obtained. The random variable x counts the number of tosses.

In Exercises 19–22, find the indicated probabilities.

19. One in four adults is currently on a diet. In a random sample of eight adults, what is the probability that the number currently on a diet is

(a) exactly three?

(b) at least three?

(c) more than three? *(Source: Wirthlin Worldwide)*

20. One in four people in the United States owns individual stocks. In a random sample of 12 people, what is the probability that the number owning individual stocks is

(a) exactly two?

(b) at least two?

(c) more than two? *(Source: Pew Research Center)*

21. Forty-three percent of adults in the United States receive fewer than five phone calls a day. In a random sample of seven adults, what is the probability that the number receiving fewer than five calls a day is

(a) exactly three?

(b) at least three?

(c) more than three? *(Source: Wirthlin Worldwide)*

22. In a typical day, 31% of people in the United States with Internet access go online to get news. In a random sample of five people in the United States with Internet access, what is the probability that the number going online to get news is

(a) exactly two?

(b) at least two?

(c) more than two? *(Source: Pew Research Center)*

In Exercises 23–26,

(a) construct a binomial distribution.

(b) graph the binomial distribution using a histogram.

(c) find the mean, variance, and standard deviation of the binomial distribution.

23. Sixty-three percent of adults in the United States rent videotapes or DVDs at least once a month. Consider a random sample of five Americans who are asked if they rent at least one videotape or DVD a month.

24. Sixty-eight percent of families say that their children have an influence on their vacation destinations. Consider a random sample of six families who are asked if their children have an influence on their vacation destinations. *(Source: YPB&R)*

25. In a recent year, forty percent of trucks sold by a company had diesel engines. Consider a random sample of four trucks sold by the company

26. In a typical day, 15% of people in the United States with Internet access check the weather while online. Consider a random sample of five people in the United States with Internet access who are asked if they check the weather while online. *(Source: Pew Research Center)*

Section 4.3

In Exercises 27 and 28, find the indicated probabilities using the geometric distribution. If convenient, use technology to find the probabilities.

27. During a promotional contest, a soft drink company places winning caps on one of every six bottles. If you purchase one bottle a day, find the probability that you find your first winning cap

(a) on the fourth day.
(b) within four days.
(c) sometime after three days.

28. In a recent year, Barry Bonds hit 73 home runs in the 153 games he played. Assume that his home run production stayed at that level the following season. What is the probability that he would hit his first home run

(a) on the first game of the season.
(b) on the second game of the season.
(c) on the first or second game of the season.
(d) within the first three games of the season. *(Source: Major League Baseball)*

In Exercises 29 and 30, find the indicated probabilities using the Poisson distribution. If convenient, use a Poisson probability table or technology tool to find the probabilities.

29. During a 36-year period, lightning killed 2457 people in the United States. Assume that this rate holds true today and is constant throughout the year. Find the probability that tomorrow

(a) no one in the United States will be struck and killed by lightning.
(b) one person will be struck and killed.
(c) more than one person will be struck and killed. *(Source: National Weather Service)*

30. It is estimated that sharks kill 10 people each year worldwide. Find the probability that at least three people are killed by sharks this year

(a) assuming that this rate is true.
(b) if the rate is actually five people a year.
(c) if the rate is actually 15 people a year. *(Source: International Shark Attack File)*

4 CHAPTER QUIZ

Take this quiz as you would take a quiz in class. After you are done, check your work against the answers given in the back of the book.

1. Decide if the random variable, x, is discrete or continuous. Explain your reasoning.

(a) x represents the number of tornadoes that occur in Kansas during the month of May.

(b) x represents the amount of waste (in pounds) generated each day in the United States.

2. The table lists the number of U.S. mainland hurricane strikes (from 1901 to 2004) for various intensities according to the Saffir-Simpson Hurricane Scale. *(Source: National Hurricane Center)*

Intensity	Number of hurricanes
1	70
2	41
3	49
4	13
5	3

(a) Construct a probability distribution of the data.

(b) Graph the discrete probability distribution using a probability histogram.

(c) Find the mean, variance, and standard deviation of the probability distribution and interpret the results.

(d) Find the probability that a hurricane selected at random for further study has an intensity of at least four.

3. A surgical technique is performed on eight patients. You are told there is an 80% chance of success.

(a) Construct a binomial distribution.

(b) Graph the binomial distribution using a probability histogram.

(c) Find the mean, variance, and standard deviation of the probability distribution and interpret the results.

(d) Find the probability that the surgery is successful for exactly two patients.

(e) Find the probability that the surgery is successful for fewer than two patients.

4. A newspaper finds that the mean number of typographical errors per page is five. Find the probability that

(a) exactly five typographical errors will be found on a page.

(b) fewer than five typographical errors will be found on a page.

(c) no typographical errors will be found on a page.